

WHAT IS CLAIMED IS:

1. A method for manufacturing a semiconductor device, comprising:
depositing a dielectric layer on a substrate, the dielectric layer having a dielectric constant greater than the dielectric constant of silicon dioxide; and
5 subjecting the dielectric layer to a plasma, the plasma operable to reduce top surface roughness in the dielectric layer.
2. The method of Claim 1, further comprising annealing the dielectric layer before subjecting the dielectric layer to the plasma.
3. The method of Claim 1, further comprising annealing the dielectric
10 layer after subjecting the dielectric layer to the plasma.
4. The method of Claim 1 where the resulting high-k comprises hafnium silicon oxy-nitride.
5. The method of Claim 1, wherein the dielectric layer comprises hafnium silicon oxide.
- 15 6. The method of Claim 1, wherein the dielectric layer comprises hafnium oxide.
7. The method of Claim 1, wherein the dielectric layer comprises a hafnium aluminum oxide.
8. The method of Claim 1, wherein the dielectric layer comprises an
20 oxide from the group of lanthanum oxide, gadolinium oxide, tantalum oxide, yttrium oxide, titanium oxide, chromium oxide, aluminum oxide, and zirconium oxide.
9. The method of Claim 1, wherein the dielectric layer comprises a ternary transition metal oxide from the group of ZrHfO, TaTiO, ZrTiO, HfNbO, HfVO, ZrVO, TaNbO, TaVO, TaNbO, HfTiO, and HfTaO.
- 25 10. The method of Claim 1, wherein the dielectric layer comprises a ternary oxide.

11. The method of Claim 1, wherein the dielectric layer has a dielectric constant greater than 3.9.

12. The method of Claim 1, wherein depositing a dielectric layer on a substrate comprises chemical vapor deposition.

5 13. The method of Claim 1, wherein depositing a dielectric layer on a substrate comprises atomic layer deposition.

14. The method of Claim 1, wherein depositing a dielectric layer on a substrate comprises physical vapor deposition.

15. The method of Claim 1, wherein the plasma is an argon plasma.

10 16. The method of Claim 1, wherein the plasma is a xenon plasma.

17. The method of Claim 1, wherein the plasma is a krypton plasma.

18. The method of Claim 1, wherein the plasma is an oxygen plasma.

19. The method of Claim 1, wherein the plasma is a nitrogen plasma, the nitrogen plasma further operable to incorporate nitrogen into the dielectric layer.

15 20. The method of Claim 1, wherein the plasma is a helium plasma.

21. The method of Claim 1, wherein the plasma is a combination of any plasmas from the group of plasmas including argon, xenon, krypton, oxygen, nitrogen, and helium.

20 22. The method of Claim 2, wherein annealing the dielectric layer further comprises using an inert plasma.

23. The method of Claim 2, wherein annealing the dielectric layer further comprises heating the dielectric layer to remove impurities.

24. The method of Claim 3, wherein annealing the dielectric layer further comprises subjecting the dielectric layer to a nitrogen plasma, the nitrogen plasma operable to incorporate nitrogen into the dielectric layer.

25. The method of Claim 1, wherein the plasma comprises a dual-
5 frequency plasma.

26. A system for manufacturing a semiconductor device, comprising:
a deposition system, the deposition system operable to deposit a film onto a
substrate, wherein the film has a dielectric constant greater than silicon oxide; and
a plasma system, the plasma system operable to expose the film to a plasma,
5 the plasma operable to reduce the top surface roughness of the film .

27. The system of Claim 26, further comprising an annealing system, the
annealing system operable to increase the temperature of the film.

28. The system of Claim 27, wherein the annealing system and the
deposition system operate simultaneously.

10 29. The system of Claim 27, wherein the plasma system and the annealing
system operate simultaneously.

30. The system of Claim 27, wherein the plasma system, annealing system,
and deposition system operate simultaneously.

15 31. The system of Claim 27, wherein the annealing system operates on the
film after the plasma system.